April 14, 2006
VS Release #06-17
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Researchers focused on proving alternative power storage for spacecraft

Flywheel experiment involves storing and converting rotational energy into electricity, as well as maintaining a satellite's desired position

By the summer of 2007, a team of eight personnel serving at the Air Force Research Laboratory's (AFRL) Space Vehicles Directorate, Kirtland Air Force Base, N.M., believe their experiment consisting of three flywheels, spinning between 16,000 and 40,000 revolutions per minute, will demonstrate the innovative technology of combined attitude control and energy storage on a satellite.

For decades, rotational disks (flywheels) have been employed as spacecraft positioning devices, but have not extensively been considered for power purposes. The success of the Flywheel Attitude Control, Energy Transmission, and Storage (FACETS) system's unique trial could change that perspective.

"I'm definitely looking forward to demonstrating the combined energy storage and attitude control capability of FACETS and showing the feasibility of something that has never been done before," said Dr. Jerry Fausz, FACETS program manager, AFRL's Space Vehicles Directorate.

Completed in February 2006, the mini-Agile Multi-Purpose Satellite Simulator (mini-AMPSS) is a three-degree-of-freedom structure weighing over a ton. Affixed on a pressurized air bearing, it serves as the testbed for the FACETS units, which will be mounted on it. Built under contract with Honeywell, the tri-flywheel arrangement will be used to store energy as momentum, supplying power through an electromagnetic drive system. The FACETS contains a device, similar to a car alternator, which will convert rotational power into electricity to operate a spacecraft's payloads. To maintain a satellite's attitude control, the system will also possess the capability to change the flywheel speed and spin axis to point mini-AMPSS in a different direction.

"The FACETS experiment represents the first full-scale, three degree-of-freedom, mission-traceable, ground demonstration that introduces the Air Force to this new concept of combined energy storage and attitude control," said Dr. Brian Wilson, a Space Vehicles Directorate electrical engineer working on the experiment. "Our successful demonstration will mature the technology through its adolescence. The excitement generated by this groundbreaking demonstration could lead to a flight experiment, further maturing the FACETS system. These are the first steps necessary in the ultimate transition of the FACETS technology to military and commercial customers in the greater aerospace community."

Within the next month, initial testing will begin on a flywheel unit, first evaluating its power production ability on a custom-built rigid test stand. By the end of this year, the three flywheels will be installed on the satellite simulator, and then their contributions to both power and attitude control will be assessed. Because the system will be tested at speeds up to 40,000 RPM, certain safety measures are necessary in case of a crack or other unexpected flywheel deterioration. The entire experiment will be housed in a 16-

foot diameter cylindrical container, consisting of a double-skinned steel wall filled with sand five inches thick. A steel roof will also cover the container, equipped with pressure relief flaps.

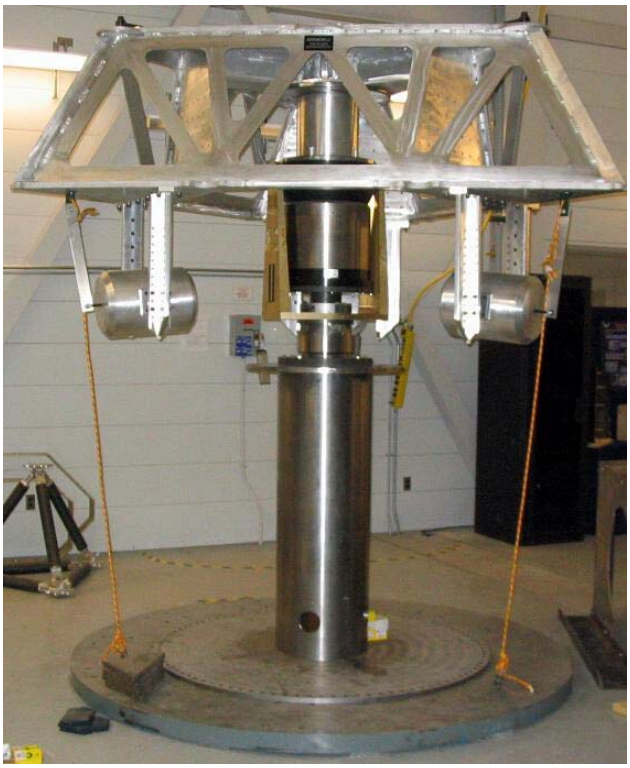
After successful demonstration, the five-year-old project's objectives of exhibiting energy storage, as well as maintaining a satellite's desired position, promise to significantly impact the warfighter's battlespace awareness. "FACETS system can point the satellite like traditional attitude control systems, and in addition, its flywheels can provide power to spacecraft payloads at levels as much as 10 times as a traditional battery-based energy storage subsystem" said Dr. Wilson. "The frictionless magnetic bearings employed in the flywheel energy storage subsystem give FACETS the ability to operate on-orbit for about twice as long as a satellite using chemical batteries."

The FACETS program's genesis dates back to the late 1980s and early 1990s with the Strategic Defense Initiative (SDI), also referred to as Star Wars after the famous science fiction films. Advancing from a space-based laser concept developed under the SDI, the Advanced Structures Experiment (ASTREX) conducted at Edwards AFB, Calif., was used by AFRL to test control of large space structures. In 1992, the initial experiments at Edwards AFB ceased. Eventually, the dormant ASTREX structure moved to the Space Vehicles Directorate at Kirtland AFB, NM. By 1997, it would become the foundation for the FACETS concept.

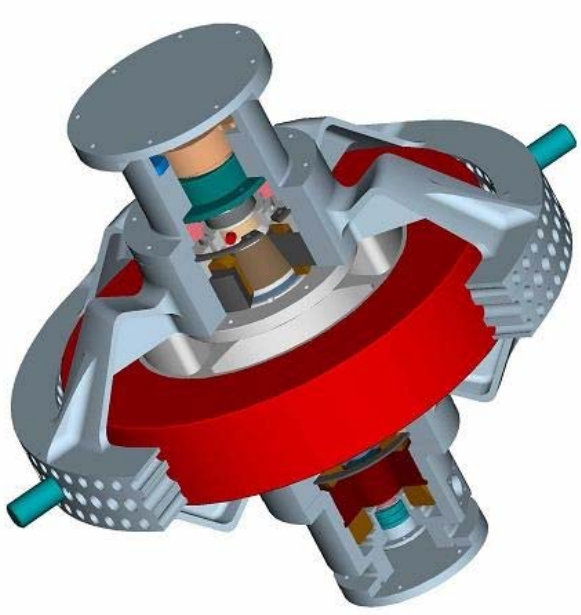
"Putting mini-AMPSS together took about eight months, and it was fun to build," said 1st Lt. Jason Kent, FACETS deputy program manager. "Our flywheels will use a power sharing system, working together to produce up to 10 kilowatts at 150 volts with an additional 2 kilowatts at 28 volts. That's a lot of power, roughly equal to what it would take to operate about seven toasters in your kitchen."

FACETS has the potential to benefit the Space Radar system. Meeting the high power levels required when the radar is operational demands significant over-sizing of the chemical batteries, which can only deliver a limited amount of power in a given time. Once the radar is inactive, the oversized batteries represent excess weight. On the other hand, flywheel systems can be designed to handle the very high peak power needs without the requirement of being oversized. They are uniquely effective at providing sudden, large amounts of power, but are not a detriment during low power mission phases. The net result is dramatically reduced combined energy storage and attitude control system weight.

"It is also important to note that flywheels are clean energy storage in comparison to chemical batteries that contain caustic and/or toxic materials. Once it is proven that flywheels can store and convert energy into electricity while simultaneously controlling satellite orientation, they will eliminate the need for heavy, chemical batteries on many satellite systems, thus significantly reducing spacecraft weight," said Dr. Fausz.



Completed mini-Agile Multi-Purpose Satellite Simulator displaying three flywheel mass simulators. (U.S. Air Force Photo)



Flywheel cutaway diagram (Graphic Courtesy of Honeywell)